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Effect of prepubertal feeding regimen on reproductive development and performance of gilts through the first pregnancy[1,2,3]

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ABSTRACT: Development of gilts that conceive early and continue to produce offspring is an objective of swine production. We investigated different patterns of growth on reproductive development and performance of gilts through the first farrowing. At 13 wk of age and 43 kg BW, 286 white crossbred gilts were penned individually and assigned to treatments: Ad lib, ad libitum intake from 13 to 25 wk of age; Control, ad libitum intake from 13 wk of age until 100 kg BW and then 90% of ad libitum intake until 25 wk of age; and Restricted, 74% of ad libitum intake from 13 wk to 25 wk of age. Feed was formulated to restrict energy intake. The study was replicated in three seasons. At 25 wk of age, gilts were moved by treatment to group pens, fed for ad libitum consumption, and estrus detection was initiated. Gilts were inseminated at first estrus, and those recycling were remated. Postmating gilts were fed 1.5× maintenance until 105 to 110 d of pregnancy. Gilts were moved either to the farrowing facility or the abattoir at 105 to 110 d of pregnancy. Those taken to the abattoir were slaughtered and number, weight, and condition of the fetuses were recorded. Gilts moved to the farrowing facility were allowed to farrow, and number, weight, and condition of the piglets were recorded. Daily feed intake during breeding was 3.4 kg/d by Restricted gilts, 2.9 by Control gilts, and 2.7 kg/d by Ad lib gilts. Increased feed intake by Restricted gilts during breeding resulted in compensatory gains that overcame the reduced reproductive performance that resulted from the reduced BW and backfat these gilts carried at the start of breeding. Days to first estrus and pregnancy were not influenced by development period treatment ($P < 0.13$). Percentage of Ad lib, Control, and Restricted gilts that successfully completed their pregnancies were 61, 74, and 66, respectively ($P > 0.19$). Total feed fed from 13 wk of age to end of the first pregnancy per gilt assigned did not differ among Ad lib (506 kg) and Control (498 kg) gilts but was less ($P < 0.01$) in Restricted gilts (451 kg). Number of piglets born per gilt assigned ($P > 0.09$) and piglets produced per kilogram of feed fed from 13 wk of age to term ($P > 0.29$) were 6.47 and 0.0134 in Ad lib gilts, 7.26 and 0.0150 in Control gilts, and 6.38 and 0.0149 in Restricted gilts, respectively. Moderate feed restriction, 74% of ad libitum intake, reduced feed consumed from 13 wk of age to end of the first pregnancy with no significant impact on efficiency of piglet production.

Key Words: Gilts, Growth, Pregnancy, Puberty

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Introduction

Adequate nutrition during growth is required for development of reproductively competent females. Previously, we reported that gilts subjected to moderate dietary restriction during the prepubertal period exhibited age at puberty and reproductive performance through 30 d of gestation similar to that of gilts fed as recommended (Reese et al., 1995) or given ad libitum access to feed (Klindt et al., 1999). In contrast, Beltranena et al. (1991) reported increased age at first estrus in gilts maintained on a restricted feed level through first estrus compared with gilts with ad libitum access to feed. Stalder and Goodwin (2000) reported a positive relationship between BW at 180 d of age and percentage of gilts exhibiting estrus. Although some gilts in the previous study (Klindt et al., 1999) were subjected to moderate dietary restriction during growth, and thus had reduced BW at the start of breeding, all gilts had ad libitum access to feed during breeding. Ad libitum feed availability during breeding al-

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lowed the previously restricted gilts to consume increased feed during the early portion of the breeding period. We hypothesize that increased feed intake resulted in greater metabolic rate and organ growth, which compensated for the deleterious effects of feed restriction during the growth period, resulting in similar reproductive performance in all groups of gilts through 30 d of gestation. Reduced feed intake combined with similar reproductive output resulted in greater efficiency of embryo production through 30 d of gestation in moderately restricted gilts.

The objective herein was to extend our previous findings and determine the effect of moderate feed restriction during a 12-wk growth and development period followed by ad libitum access to feed during breeding on reproductive performance through the end of the first pregnancy in gilts.

Materials and Methods

Crossbred white (American Landrace × Yorkshire) gilts were used in the study. The study was replicated with gilts born in three farrowing seasons. Selected litters contained at least three gilts that were used for the study. Average birth dates were July 12 (SD = 1.7 d, n = 96), January 11 (SD = 4.7 d, n = 95), and July 13 (SD = 2.4 d, n = 95). Two hundred eighty-six gilts were selected at approximately 12 wk of age and assigned to three treatments: **Ad lib**, ad libitum intake from 13 to 25 wk of age, n = 94; **Control**, gilts fed as recommended by Reese et al. (1995), i.e., ad libitum intake from 13 wk of age until approximately 100 kg BW, then approximately 90% of ad libitum intake until 25 wk of age, n = 96; and **Restricted**, 74% of ad libitum intake from 13 to 25 wk of age based on BW and feed consumption of the Ad lib gilts, n = 96 (Klindt et al., 1999). The experimental design was a randomized complete block with litter as the blocking criterion. At initiation of development period treatments, age was 93.6 d (SD = 3.3) and BW was 43.1 kg (SD = 6.3). Corn-soybean meal rations were formulated to meet National Research Council (NRC, 1988) recommendations (Table 1). The rations offered the Restricted gilts from 13 wk of age until 80 kg BW were formulated so that the quantity of metabolizable energy offered during the development period was approximately 74% of that consumed by Ad lib gilts, on a BW basis, but without a reduction in available protein, vitamins, or minerals. At 2-wk intervals, during the development period, feed intake was recorded, gilts were weighed, and backfat was determined ultrasonically approximately 35 mm lateral to the midline at three sites: first rib, last rib, and last lumbar vertebrae (Lean-Meater, Renco Corp., Minneapolis, MN). The three backfat measures were averaged to obtain average backfat thickness. The quantity of feed offered gilts subjected to feed restriction (Restricted group gilts and Control group gilts weighing more than 100 kg) was adjusted every 2 wk. During development gilts were housed in individual pens (1.2 × 1.2 m) in an enclosed temperature-controlled building (~21°C, SD = 3.6) with free access to water. All animal procedures were reviewed and approved by the U.S. Meat Animal Research Center Animal Care and Use Committee.

At an average age of 25 wk (end of the development period) gilts were loaded onto a trailer and transported approximately 300 m to a breeding facility and placed in group pens (3.66 × 6.71 m); all were offered feed for ad libitum consumption. Gilts were group-penned by heavier and lighter BW within treatment group with initially 16 gilts per breeding pen. In the breeding pens gilts were fed with self-feeders and the quantity of feed offered and number of gilts in each pen were recorded daily. Gilts were weighed and backfat thickness was determined by ultrasound weekly as described above. Inseminated gilts were weighed and backfat was determined at the first weigh day after each insemination.

Morning estrous checks using 10 to 15 min of fence-line boar exposure, back pressure, and observation of behavior were begun the day after gilts were moved to the breeding facility. The day of first detected estrus was considered the pubertal estrus, and day of estrus was designated d 0 of gestation if the gilts became pregnant. Gilts in estrus were moved to stalls and inseminated on the afternoon of d 0 and the following morning. Gilts were inseminated at the first and subsequent estruses that occurred during the 49-d breeding period. After insemination gilts were fed 158 kcal ME/kg $BW^{0.75}$ (Jindal et al., 1996) of a corn-soybean meal ration (Table 1). From d 17 to 30 after insemination gilts were checked for estrus using a mature boar, back pressure, and observation. Gilts that did not return to estrus were considered pregnant. Gilts that returned to estrus before d 30 after insemination and before the end of the 49-d breeding period were inseminated again, as described previously. All gilts in which no estrus was detected or that were considered non-pregnant were slaughtered at the end of the 49-d breeding period. In the abattoir the reproductive tracts were collected and ovarian structures and uterine normalcy were recorded. When gilts were 30 to 50 d pregnant they were moved to gestation pens, five gilts/pen, 1.36 m^2/gilt. For assignment to gestation pens, gilts were stratified by breeding date and BW, ignoring treatment. In gestation pens, pregnant gilts were fed 158 kcal ME/kg $BW^{0.75}$ based on the average BW of the five gilts in the pen until 90 d of gestation. Between d 90 of gestation and farrowing or slaughter the pregnant gilts were fed 2.7 kg feed/d.

Gilts were managed as the general swine herd was managed with respect to herd health considerations, except timing of immunizations and inseminations was advanced approximately 60 d. Gilts in the general swine herd were inseminated between 240 and 260 d of age. Gilts were immunized against parvo virus,

Table 1. Rations fed to gilts during the stages of growth and periods of the study

Item	Ad lib and Control gilts: 13 wk of age to 60 kg BW	Ad lib and Control gilts: 60 to 80 kg BW	Ad lib and Control gilts: 80 kg BW to 25 wk of age	Restricted gilts: 13 wk of age to 60 kg BW	Restricted gilts: 60 to 80 kg BW	Restricted gilts: 80 kg BW to 25 wk of age	All gilts: Breeding and gestation
Ingredient composition							
Corn, %	81.92	85.23	87.45	74.38	79.27	81.92	78.52
Soybean meal (44% CP), %	13.42	11.07	9.11	20.40	15.64	13.42	12.59
Dicalcium phosphate, %	1.89	1.45	1.48	1.80	1.87	1.89	2.91
Limestone, %	0.77	0.75	0.75	0.77	0.77	0.77	0.69
Alfalfa, %	—	—	—	—	—	—	2.00
Choline chloride, %	0.10	0.10	0.10	0.10	0.10	0.10	0.20
L-Lysine, %	0.30	0.26	0.20	0.40	0.40	0.30	—
Methionine, %	0.07	0.06	0.01	0.15	0.14	0.07	—
Salt, %	0.30	0.30	0.30	0.30	0.30	0.30	0.50
Soybean oil, %	0.75	0.33	0.18	1.13	0.97	0.75	2.00
Threonine, %	0.04	0.03	—	0.11	0.10	0.04	—
Trace mineral H, %[a]	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Vitamin Premix #10, %[b]	0.20	0.20	0.20	0.20	0.20	0.20	—
Vitamin Premix #11, %[c]	—	—	—	—	—	—	0.20
Tylosin, %	0.05	0.03	0.03	0.05	0.05	0.05	—
Chlortetracycline, %	—	—	—	—	—	—	0.02
Calculated nutrient composition							
Dry matter, %	88.54	88.42	88.36	88.78	88.68	88.54	88.64
Crude protein, %	13.60	12.80	12.00	16.26	14.58	13.60	12.30
Crude fat, %	3.68	3.37	3.29	3.83	3.82	3.68	4.96
Crude fiber, %	3.32	3.25	3.17	3.59	3.40	3.32	3.65
Calcium, %	0.750	0.650	0.650	0.751	0.749	0.750	0.950
Total P, %	0.636	0.548	0.546	0.642	0.637	0.636	0.810
Available P, %	0.380	0.300	0.300	0.380	0.380	0.380	0.550
Digestible cystine, %	0.158	0.150	0.142	0.184	0.166	0.158	0.143
Digestible lysine, %	0.680	0.600	0.510	0.918	0.811	0.680	0.530
Digestible methionine, %	0.275	0.256	0.198	0.389	0.359	0.275	0.213
Digestible tryptophan, %	0.122	0.111	0.102	0.155	0.132	0.122	0.109
Digestible Met + Cys, %	0.433	0.405	0.340	0.573	0.524	0.433	0.356
Metabolizable energy, Mcal/kg	3.304	3.304	3.304	3.304	3.304	3.304	3.304

[a]Percentage of ingredient in the premix: Ferrous sulfate monohydrate, 35.05; copper sulfate pentahydrate, 1.77; manganese oxide, 2.61; zinc oxide, 9.62; sodium selenite, 0.033; calcium carbonate, 50.91.

[b]Quantity of ingredient per kg of premix: Vitamin A, 2,200,000 IU; vitamin D_3, 440,000 IU; vitamin E, 17,600 IU; vitamin K, 2,200 mg; niacin, 22,000 mg; d-pantothenic acid, 12,100 mg; riboflavin, 4,400 mg; vitamin B_{12}, 22 mg.

[c]Quantity of ingredient per kg of premix: Vitamin A, 3,300,000 IU; vitamin D_3, 440,000 IU; vitamin E, 22,000 IU; vitamin K, 2,200 mg; niacin, 11,000 mg; d- pantothenic acid, 12,100 mg; riboflavin, 3,740 mg; vitamin B_{12}, 22 mg; d-biotin, 165 mg; folic acid, 1,100 mg.

leptospirosis, and erysipelas (PLE), *Mycoplasmal hypopneumoniae*; *Actinobacillus pleuropnuemoniae*; and porcine reproductive and respiratory syndrome (**PRRS**). Exposure to four to six mature sows from the general herd that had weaned at least one litter was initiated at approximately 19 wk of age.

At approximately 105 to 110 d after insemination, pregnant gilts were moved either to the farrowing facility or to the abattoir. Gilts whose insemination dates allowed farrowing within the available time in the farrowing facility were farrowed. The others were slaughtered. Gilts in the farrowing facility were allowed to farrow and nurse their offspring for 15 to 21 d. Postfarrowing data are not presented because there were considerable losses due to disease. Numbers and conditions of the fetuses were recorded for gilts that were slaughtered. Gilts that were considered pregnant (i.e., gilts that did not return to estrus within 30 d of insemination) and did not farrow or were not pregnant at the time of slaughter were considered to have aborted.

Statistical analyses of the results were performed using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). The models included effects of development period treatment group, farrowing season when the gilts were born, and litter within farrowing season. In some analyses, some of the values were zero (e.g., analysis of number born for all gilts assigned number born was zero for gilts that did not produce piglets, and gestational feed intake by gilts that did not become pregnant was zero). In analysis of day to first estrus, day of pregnancy, BW and average backfat thickness at first estrus of pregnancy, and BW and average backfat gain to first estrus or pregnancy, gilts that did not exhibit a first estrus or did not become pregnant were excluded from the analysis. Differences between treatment group means were examined by the nonorthogonal contrasts presented in the tables. Temporal patterns of cumulative feed intake, body weight, ADG, backfat thickness, and efficiency of gain were analyzed by split-plot analysis of variance (Gill and Hafs, 1971).

Results

Two hundred eighty-six gilts were assigned to treatments, and 95 gilts (33.2%) were removed for various reasons (Table 2). Reason for gilt removal was not influenced by treatment ($P > 0.15$).

Growth of the gilts during the development period was affected by treatment (Figure 1). During this period, Control gilts consumed 222.6 kg of feed/gilt. Ad lib gilts consumed 5.7% ($P < 0.01$) more, whereas Restricted gilts consumed 25.6% ($P < 0.01$) less (Table 3). These differences in feed consumption resulted in Ad lib gilts weighing 4.7% ($P < 0.01$) more than Control gilts (115.6 kg) and Restricted gilts weighing 14.5% ($P < 0.01$) less at the end of the development period (Table 4). Gilts with ad libitum access to feed during the development period maintained consistant rates of gain. When Control gilts reached 100 kg BW they were restricted to 90% of ad libitum intake and their rates of gain decreased (Figure 1). Restricted gilts had the lowest rate and efficiency of BW gain during the first 14 d of the development period but subsequently improved (Figure 1). Average backfat thickness at the end of the development period differed ($P < 0.05$) among the development treatment groups (Table 4).

Differences in BW and backfat thickness induced by level of feed during the development period resulted in differences in feed consumption and BW and backfat gains in the breeding facility. Average daily feed intake by Restricted gilts in the breeding facility was approximately 18% ($P < 0.02$) greater than that of Control gilts (Table 3); the greatest differences were seen early in the breeding period. Daily feed consumption by Ad lib gilts was approximately 7% less than that of Control gilts (Table 3). Average BW and backfat thickness gains from the start of breeding, 25 wk of age, to first detected estrus did not differ in Ad lib and Control gilts but were greater in Restricted gilts ($P <$ 0.01 to 0.08, Table 4).

Table 2. Numbers and percentages of gilts removed from the study

		Treatment group[a]			
Reason removed	All	Ad Lib	Control	Restricted	Trt, P
No detected estrus					
n	31[b]	13	6	12	0.40[d]
%	10.8[c]	13.7	6.3	12.5	
Pubertal/not pregnant					
n	13	3	4	6	0.55
%	4.5	3.2	4.2	6.3	
Aborted					
n	32	13	10	9	0.29
%	11.2	13.9	10.4	7.3	
Lame					
n	8	3	4	1	0.29
%	2.8	3.1	4.2	1.0	
Prolapse					
n	3	2	0	1	0.25
%	1.2	2.1	0.0	1.0	
Sick					
n	2	0	1	1	0.70
%	0.7	0.0	1.0	4.0	
Died					
n	5	3	0	2	0.29
%	1.7	3.2	0.0	2.1	
Infantile vagina					
n	1	0	0	1	0.45
%	0.3	0.0	0.0	1.0	
All reasons					
n	95	37	25	33	0.15
%	33.2	39.3	26.0	34.4	

[a]Treatment groups: Ad lib, ad libitum intake from 13 to 25 wk of age; Control, ad libitum intake from 13 wk of age to 100 kg BW and then 90% of ad libitum intake until 25 wk of age; Restricted, fed at 74% of ad libitum intake from 13 to 25 wk of age.

[b]Total number of gilts in the category.

[c]Percentage of the gilts assigned to the treatment group that are in the category.

[d]Probability that the effect of treatment group is not different from zero. The analytical model was Number removed = treatment + farrowing group.

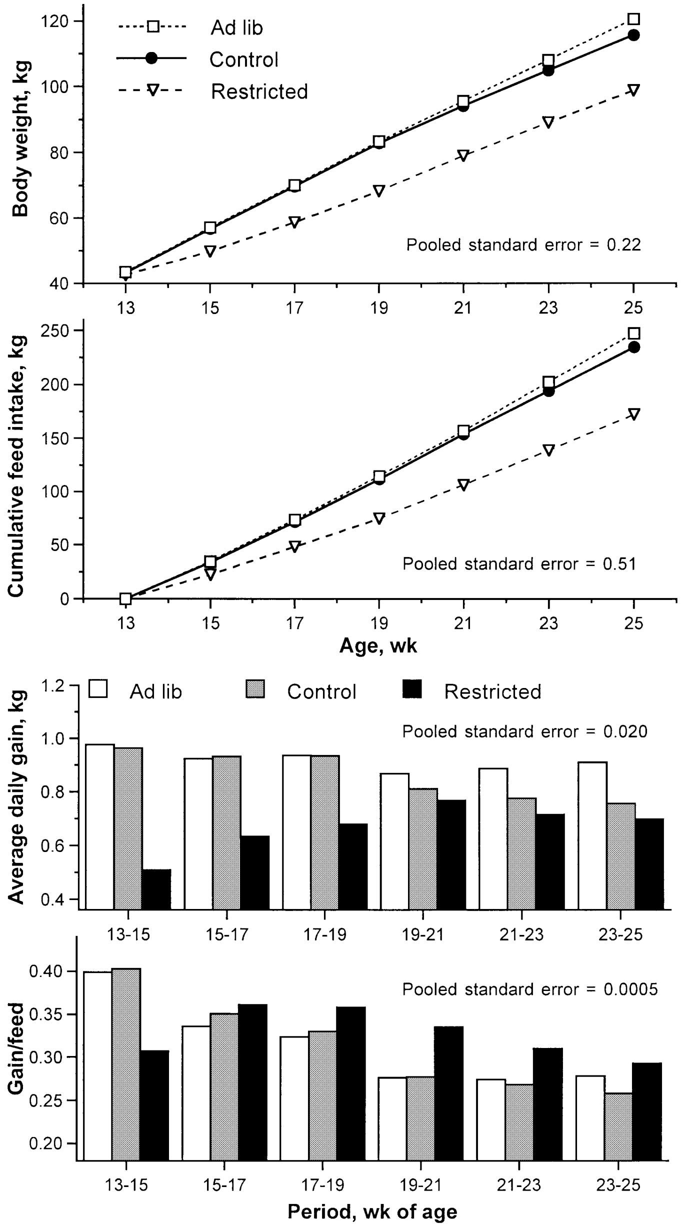

Figure 1. Body weight (top panel), cumulative feed intake (second panel), daily gain during each 2-wk period (third panel), and efficiency of conversion of feed to body weight (bottom panel) in gilts during the development period, 13 to 25 wk of age. Treatment groups were: Ad lib, ad libitum intake from 13 to 25 wk of age; Control, ad libitum intake from 13 wk of age to 100 kg BW and then 90% of ad libitum intake until 25 wk of age; Restricted, fed at 74% of ad libitum intake from 13 to 25 wk of age. Interactions of treatment and week of age or period of development were significant ($P < 0.05$) for all measures.

The differences in BW, backfat thickness, rates of BW and backfat gain, and level of feed intake during the breeding period induced by the level of feed during the development period resulted in few differences in reproductive performance of the gilts in the breeding facility. Days of the breeding period when gilts exhibited first detected estrus (average = 20.1 d) and when gilts became pregnant (average = 22.4 d) were not influenced ($P > 0.14$) by development period treatment. Control gilts consumed more feed than Ad lib gilts ($P < 0.06$) during gestation when expressed per gilt assigned or gilt entering breeding due to the greater number of Control gilts that became pregnant and the fewer zeros in those means. Regardless of the basis for examining production results (all gilts assigned to the study, gilts entering breeding, pubertal gilts, gilts considered pregnant, or gilts completing their pregnancy), treatment had little influence ($P <$ 0.08 to 0.98) on number of piglets delivered at slaughter or term (Table 3). Similarly, development period treatment had little influence on efficiency of piglet production (Table 3). At the end of pregnancy there were no differences ($P > 0.20$) among the development period treatment groups in BW or average backfat thickness (Table 4).

The temporal patterns of BW and average backfat gain differed for the three treatment groups (Figure 2). All gilts had similar BW and backfat thickness at the start of the study. However, differences were present among the development period treatment groups in BW and backfat thickness at the start of breeding, at the time of first estrus and establishment of pregnancy (Table 4). At the end of pregnancy no differences were evident in BW and backfat thickness. Although Restricted gilts consumed 12% less feed from 13 wk of age until the end of pregnancy than Control gilts, their BW was only 1% less at the end of pregnancy.

Discussion

Of the gilts assigned to the study, 83% exhibited estrus, 79% conceived, and 67% were pregnant at farrowing or slaughter at the end of pregnancy. Maximal age at scheduled farrowing date was 338 d. Although this level of success is lower than desired, it may not be a deviation from production norms. Stalder et al. (2000) reported that 60% of gilts (422/708) assigned to a nutrition- reproduction trial farrowed after an 80-d breeding period initiated at 200 d of age. In a large study, 79% (2,605/3,283) of the gilts farrowed after a breeding period that extended from 205 to 300 d of age (Goodwin and Boyd, 2000). Additionally, the number of gilts, herein, that were considered pregnant and did not achieve term pregnancy was greater than expected (11.2% of gilts assigned) because disease (PRRS and parvovirus) inflicted considerable unexpected neonatal death loss. These disease problems and high neonatal death losses seem to be a consequence of breeding at an early age in this particular management unit.

At the end of the development period, Restricted gilts were lighter in weight and had reduced backfat thickness compared with Control or Ad lib gilts. During the breeding period, daily feed consumption by

Table 3. Least squares means for feed intake and piglet production by gilts during the different developmental periods for groups of gilts by the various bases for analysis of the results

Basis for analysis	Treatment group[a] Ad lib	Control	Restricted	PSE[c]	Contrasts[b] Ad lib vs Control	Control vs Restricted	Ad lib Restricted
All gilts assigned							
No./treatment group	94	96	96				
Growing phase, kg/pig	235.2	222.6	165.6	2.6	0.01[c]	0.01	0.01
Breeding							
kg/pig	66.2	70.0	85.4	4.7	0.61	0.01	0.01
$kg/d \cdot pig^{-1}$	2.70	2.87	3.38	0.09	0.16	0.01	0.01
Gestation, kg/pig	147.2	168.2	145.6	8.1	0.06	0.04	0.89
Total feed, kg/pig	448.5	460.8	396.6	8.7	0.30	0.01	0.01
No. born	6.47	7.26	6.38	0.44	0.10	0.15	0.82
Efficiency of piglet production, piglets/kg feed	0.0134	0.0150	0.0149	0.0011	0.30	0.95	0.33
Entered breeding							
No./treatment group	93	94	95				
Growing phase, kg/pig	236.8	223.2	165.5	2.2	0.01	0.01	0.01
Breeding							
kg/pig	66.5	70.8	86.9	4.1	0.50	0.01	0.01
$kg/d \cdot pig^{-1}$	2.73	2.93	3.42	0.08	0.05	0.01	0.01
Gestation, kg/pig	148.8	171.2	146.3	8.0	0.04	0.02	0.82
Total feed, kg/pig	452.0	465.9	398.6	8.7	0.20	0.01	0.01
No. born	6.55	7.41	6.41	0.52	0.22	0.15	0.84
Efficiency of piglet production, piglets/kg feed	0.0136	0.0154	0.0150	0.0011	0.26	0.82	0.36
Exhibited estrus							
No./treatment group	74	84	78				
Growing phase, kg/pig	233.9	222.6	167.1	2.2	0.01	0.01	0.01
Breeding							
kg/pig	59.6	67.2	72.6	3.8	0.21	0.35	0.04
$kg/d \cdot pig^{-1}$	2.73	2.93	3.49	0.07	0.08	0.01	0.01
Gestation, kg/pig	188.1	191.9	178.5	3.5	0.48	0.02	0.09
Total feed, kg/pig	481.6	481.8	418.2	5.4	0.99	0.01	0.01
No. born	8.35	8.17	7.69	0.44	0.79	0.47	0.34
Efficiency of piglet production, piglets/kg feed	0.0171	0.0168	0.0180	0.0010	0.85	0.42	0.56
Became pregnant							
No./treatment group	71	81	73				
Growing phase, kg/pig	233.8	222.6	166.6	2.2	0.01	0.01	0.01
Breeding							
kg/pig	60.0	66.8	70.8	3.9	0.27	0.51	0.09
$kg/d \cdot pig^{-1}$	2.72	2.92	3.53	0.06	0.06	0.01	0.01
Gestation, kg/pig	189.1	195.3	185.8	2.6	0.13	0.02	0.45
Total feed, kg/pig	482.9	484.7	423.2	5.1	0.82	0.01	0.01
No. born	8.38	8.41	8.17	0.42	0.97	0.72	0.76
Efficiency of piglet production, piglets/kg feed	0.0171	0.0173	0.0192	0.0009	0.88	0.20	0.17
Completed pregnancy							
No./treatment group	57	71	63				
Growing phase, kg/pig	232.6	223.4	167.8	2.3	0.02	0.01	0.01
Breeding							
kg/pig	60.6	68.4	72.7	3.9	0.25	0.52	0.09
$kg/d \cdot pig^{-1}$	2.75	2.93	3.58	0.07	0.14	0.01	0.01
Gestation, kg/pig	195.0	198.3	188.6	1.8	0.28	0.01	0.04
Total feed, kg/pig	488.3	490.1	429.1	5.0	0.83	0.01	0.01
No. born	10.25	9.26	9.25	0.32	0.08	0.99	0.08
Efficiency of piglet production, piglets/kg feed	0.0210	0.0191	0.0218	0.0007	0.13	0.03	0.54

[a]Treatment groups: Ad lib, ad libitum intake from 13 to 25 wk of age; Control, ad libitum intake from 13 wk of age to 100 kg BW and then 90% of ad libitum intake until 25 wk of age; Restricted, fed at 74% of ad libitum intake from 13 to 25 wk of age.
[b]Probability that the treatment group means contrasted are not different.
[c]Pooled standard error of the mean.

Table 4. Least squares means for age at start of breeding, days to puberty and pregnancy, and body weight and average backfat thickness at puberty and pregnancy

	Treatment group[a]				Contrasts[b]		
Item	Ad lib	Control	Restricted	PSE[c]	Ad lib vs Control	Control vs Restricted	Ad lib vs Restricted
Age at 25 wk of age, d	178.3	178.4	178.5	0.1	0.58[c]	0.33	0.13
Puberty, d of breeding period	19.5	22.2	20.0	1.3	0.18	0.25	0.81
Pregnancy, d of breeding period	22.1	24.7	21.6	1.4	0.22	0.14	0.81
BW at 25 wk of age, kg	121.0	115.6	98.9	0.9	0.01	0.01	0.01
BW at puberty, kg	121.9	121.2	117.2	1.3	0.74	0.04	0.02
ADG, 25 wk of age to puberty, kg/d	0.50	0.51	1.21	0.25	0.99	0.07	0.08
BW at pregnancy, kg	120.9	120.9	116.6	1.2	0.99	0.03	0.04
ADG, 25 wk of age to pregnancy, kg/d	0.27	0.53	1.11	0.18	0.40	0.06	0.01
BW at end of pregnancy, kg	171.5	168.8	166.8	2	0.53	0.64	0.29
AvBF[d] at 25 wk of age, mm	24.3	23.3	18.3	0.3	0.02	0.01	0.01
AvBF at puberty, mm	23.5	23.2	20.8	0.4	0.57	0.01	0.01
AvDBF[e], 25 wk of age to puberty, mm/d	−0.076	−0.228	0.096	0.111	0.38	0.06	0.33
AvBF at pregnancy, mm	23.3	23.2	20.5	0.4	0.84	0.01	0.01
AvDBF, 25 wk of age to pregnancy, mm/d	−0.078	−0.014	0.069	0.023	0.10	0.03	0.01
AvBF at end of pregnancy, mm	22.6	22.1	22.2	0.5	0.63	0.92	0.20

[a]Treatment groups: Ad lib, ad libitum intake feeding from 13 to 25 wk of age; Control, ad libitum intake from 13 wk of age to 100 kg BW and then 90% of ad libitum intake until 25 wk of age; Restricted, fed at 74% of ad libitum intake from 13 to 25 wk of age.
[b]Probability the treatment group means contrasted are not different.
[c]Pooled standard error of the mean.
[d]Average backfat thickness.

Restricted gilts was greater than that of the Ad lib or Control gilts. As a consequence of greater daily feed consumption, Restricted gilts had greater BW and backfat thickness gains during breeding than those in other groups. Additionally, during the breeding period, gains by Restricted gilts were greater than those they exhibited during the development period. In contrast, BW and backfat thickness gains by Ad lib and Control gilts were less during the breeding period than during the development period. Differences in rates of gains during the breeding period resulted in smaller differences in BW and backfat thickness among the treatment groups at the time of first estrus and initiation of pregnancy than at the start of the breeding period.

Pubertal development of gilts was similar for the treatment groups. Ad lib and Control gilts entered the breeding facility with adequate or more than adequate lean body mass and backfat stores for reproduction, as evidenced by their reproductive performance. Actually, gilts in the Ad lib and Control groups lost backfat thickness from the time they entered the breeding facility and time of first detected estrus. The Restricted gilts would have been expected to have reduced reproductive performance due to their reduced BW, 14% (16.7 kg) less than that of Control gilts. Rozeboom et al. (1995) and Goodwin and Boyd (2000) reported that lighter-weight, leaner gilts exhibit first estrus at later ages than heavier, fatter gilts. In their studies the weight and fatness differences were the result of individual genetic plus environmental interactions, not the consequence of feed restriction, as was imposed in the present study. However, although Restricted gilts entered the breeding facility carrying less BW and backfat stores, their greater aggressiveness in consumption of feed resulted in the greater rates of gain in BW and backfat thickness during the breeding period (compensatory growth) and greater metabolic rate and vital organ mass (Koong et al., 1982). These feed intake and subsequent metabolic responses allowed the Restricted gilts to exhibit estrus at the same age as Ad lib and Control gilts. Previously, Beltranena et al. (1991) reported that gilts restricted to 2 $kg\cdot d^{-1}\cdot gilt^{-1}$ of a 3.0 Mcal ME/kg diet, a restriction greater than that imposed herein, without ad libitum access to feed at the start of the breeding period, did not exhibit the superior gains exhibited by the Restricted gilts in the present study, and thus demonstrated delayed first estrus. Gilts in the Beltranena et al. (1991) study were not given the opportunity to exhibit compensatory growth, as were the gilts in this study.

Previously, we (Klindt et al., 1999) reported an effect of week of the breeding period on reproductive performance of similarly managed gilts of the same population measured at 30 d of gestation. Herein, reproductive performance to the end of pregnancy was similarly analyzed by time within the breeding period when pregnancy was established, and no effect of time of successful insemination was detected. Differences in reproductive performance that existed at 30 d of gestation in the previous study (Klindt et al., 1999) were not evident at the end of pregnancy. Christenson et al. (1987) reported fetal losses between d 86 of gestation and farrowing in gilts. Thus, embryonic/fetal loss is a continuous process that occurs throughout pregnancy. Treatment differences that were evident at 30 d of gestation in the previous study were not present at the end of pregnancy (Klindt et al., 1999) in the present study, suggesting treatment-specific differences in embryonic/fetal losses between d 30 and the end of pregnancy. If one assumes the reproductive performance of the present gilts and those in the previous study (Klindt et al., 1999) were the same, then these apparent embryonic losses after d 30 were influenced by treatment (27% in Ad lib, 20% in Control, and 49% in Restricted gilts).

All gilts had similar BW and backfat thickness at the start of the study and the end of pregnancy, with large differences in these traits at the start of breeding and at the time of insemination. Although Restricted gilts consumed 12% less feed from 13 wk of age until the end of pregnancy, their BW was only 1% less at the end of pregnancy, suggesting that efficiency of conversion of feed to BW gain was greater in the Restricted than in the Control or Ad lib gilts over the entire trial (Figure 2).

Previously, we (Klindt et al., 1999) presented evidence that Restricted gilts were more efficient (embryos/kilogram of feed) producers of 30-d-old embryos. However, in the present study, when efficiency was defined as piglets at the end of pregnancy per kilogram of feed fed from 13 wk of age to the end of pregnancy, efficiency, whether based on all gilts assigned, gilts at breeding, or pubertal gilts, did not differ among treatment groups. The only difference in efficiency of piglet production was between Control and Restricted gilts that completed their pregnancy ($P < 0.03$). Differences among treatment groups at 30 d of gestation were not maintained throughout gestation. Uterine development or some other aspect of uterine- placental function may have been compromised by the Restricted treatment, which was imposed during the development period.

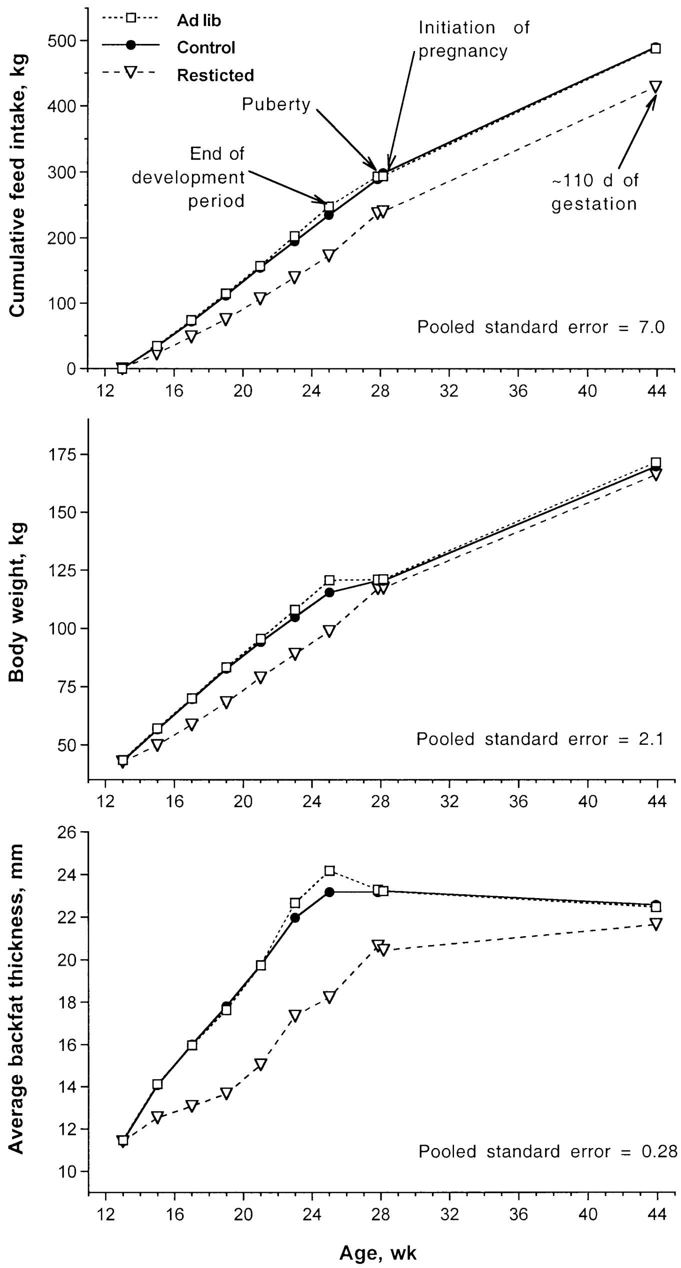

Figure 2. Least squares means for cumulative feed intake, body weight, and average backfat thickness throughout the study in gilts assigned to the prepubertal development period treatments. The treatments were: Ad lib, ad libitum intake from 13 to 25 wk of age; Control, ad libitum intake from 13 wk of age to 100 kg BW and then 90% of ad libitum intake until 25 wk of age; Restricted, fed at 74% of ad libitum intake from 13 to 25 wk of age. Values for "Puberty," "Initiation of pregnancy," and "~110 d of gestation" are at the average age for all treatments. Interactions of treatment and week of age were significant ($P < 0.05$) for all traits.

Implications

Moderate nutrient restriction imposed on Restricted gilts during the development period saves feed and prepares gilts to exhibit a compensatory gain or flushing effect during the breeding period that compensates for the reduced lean body mass and fatness they carry into the breeding period. Efficiency of piglet production through the end of pregnancy was greater in gilts of the Control and Restricted groups than in gilts fed for ad libitum consumption during development. Proper manipulation of feeding strategies during prepubertal growth, breeding, and gestation periods may allow better reproductive management of gilts.

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